DOCUMENT RESUME

ED 349 088 PS 020 596

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TITLE Motor, Sleep/Wake and Physiological Organization in Very Low Birth Weight Infants Given Developmental Care. Conference Draft.
PUB DATE May 92
NOTE 20p.; Paper presented at the Meeting of the International Society of Infant Studies (Miami, FL, May 1992). Research supported by the Meriter Medical Surgical Foundation, the Meriter Hospital Auxiliary, the University of Wisconsin-Madison School of Nursing, and the Wisconsin Perinatal Foundation.
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PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Behavior Development; *Birth Weight; Motor Development; *Neonates; *Nurses; Nursing Research; *Perinatal Influences; Physical Development; *Premature Infants; Sleep; *Stress Variables
IDENTIFIERS *Intensive Care Nursing; Morbidity

ABSTRACT

This study examined the effect of a modification of nursing care on stressors associated with care procedures for low birth weight infants in a neonatal intensive care unit (NICU); and on infants' physiological, motor, and behavioral development. The nursing staff of an NICU received training to reduce environmental and procedural stress, support motor development, and support organization of infants' patterns of sleep and wakefulness. A control group of 21 infants who weighed less than 1,501 grams at birth was cared for before the training, and an experimental group of 24 similar weight infants was cared for after the training. The range of infants' gestational ages at birth was 26 to 33 weeks, and at discharge from the hospital, 33 to 56 weeks. The study data are presented for 30, 32, and 34 weeks. Results indicated that blood oxygen levels at 30 and 34 weeks were higher for experimental than control infants. Experimental infants exhibited less jerky movement at 30 and 32 weeks, and more flexor movement at all ages, than did control infants. Experimental infants spent more time in the alert wakeful state at 34 weeks than did control infants. A list of 42 references is provided. (BC)

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CONFERENCE DRAFT

Motor, Sleep/Wake and Physiological Organization in Very Low Birth Weight Infants Given Developmental Care

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This research was supported by grants from the Meriter Medical Surgical Foundation, the University of Wisconsin-Madison School of Nursing, the Meriter Hospital Auxiliary, and the Wisconsin Perinatal Foundation. The authors express thanks to the nurses, infants, and families who participated in the study, and to Shinya Kameshima, PhD, Jan Lathrop, MS, and Chris Halvorsen, BA, for assistance with data analysis. Reprint requests may be sent to Dr. Patricia Becker, Center for Health Sciences, 600 Highland Avenue, Madison, WI 53792.

PS 020596

Key words: low birth weight infant, infant stress, developmental care

Presented at the International Society of Infant Studies, Miami, FL, May 1992.

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Abstract

A portion of the developmental morbidity experienced by very low birth weight infants may be related to stressors associated with care procedures in the NICU. The purpose of this study was to determine whether modifying care to reduce those stressors and support development could positively affect physiological, motor and behavioral state organization. Twenty one infants less than 1501 gms were studied prior to a nursing staff training program (control); 24 infants were studied post-training (study). Nurses were trained to lower environmental stress, reduce procedural stress, support motor development, and support sleep/wake organization. Nurse and infant behavior was sampled biweekly during routine care. Measures included cardiorespiratory and blood oxygen values, quality of motor activity and distribution of sleep/wake states.

Nurse behavior changed positively from control to study period. Blood oxygen levels were higher for study infants. Total movement did not differ, but study infants had less jerky and more flexor movement than controls. Movements were more organized with support than without. Alert wake was higher by 34 weeks gestational age for study infants. Results supplement positive findings for medical, growth and neurobehavioral outcomes reported earlier, and suggest that developmental care has the potential to reduce longterm developmental morbidity.

Motor, Sleep/Wake and Physiological Organization in Very Low Birth Weight Infants Given Developmental Care

The development of the low birth weight infant during initial hospitalization has typically been viewed as a period of recovery from illness. Accordingly, basic routine care within most neonatal intensive care units (NICUs) has remained focused on the technology to ensure survival, medical recovery, and physical growth, and the caretaking skills that have been rewarded are those needed to use that technology successfully. However, longterm follow-up studies of these infants are showing that ensuring recovery and growth are not sufficient to protect the child from subsequent developmental abnormality. There is accumulating evidence that among the approximately 60% of infants who appear to survive with no continuing cognitive or neuromotor problems (Aylward, Pfeiffer, Wright, & Verhulst, 1989), between 40 and 60% will experience some form of information processing, attention-related, or behavioral disorder that may not become evident until preschool or school age (McCormick, Gortmaker, & Sobol, 1990). This broader spectrum of morbidity suggests that more attention needs to be directed towards the fetal-infant's psychological development.

It is now felt that some portion of the morbidity experienced by low birth weight infants may be due to subtle injury and/or alterations in brain development resulting from exposure to the highly technical environment required to support survival and recovery (Cornell & Gottfried, 1976; Duffy, Mower, Jensen, & Als, 1984; Wolke, 1987). It is hypothesized that stressors inherent in intensive care procedures may not only result in injury to the immature brain, but may also lead to alterations in what Greenough et al. (1987) have termed experience dependent neuronal patterning. Since the NICU also presents a pattern of stimulus input incongruent with that to which the human brain is preadapted, it may also alter experience expectant patterning (Greenough et al., 1987).

Numerous studies have now documented characteristics of the NICU environment that are potentially stressful and/or inappropriate for normal development (Wolke, 1987). For example, ambient noise levels, both in the NICU and within isolettes, have been shown to exceed those comfortable for adults (Bess, Finlayson-Peek, & Chapman, 1979), while commonly occurring bursts of noise cause oxygen desaturation, bradycardia, apnea, and increased intracranial pressure (Lawson, Daum, & Turkewitz, 1977; Long, Lucey & Phillip, 1980). Constant bright light levels that are above those recommended for normal newborn nurseries may contribute to retinopathy of prematurity (Glass et al., 1985), and while others have not replicated this finding (Ackerman, Sherwont & Williams, 1989), animal studies do show retinal damage at equivalent levels (Lerman, 1985). The constancy of light levels may also interfere with developing rhythms in the behavioral states, as indicated by evidence for more optimal state development when light levels are reduced and a diurnal pattern is introduced in combination with undisturbed rest periods (Fajardo, Browning, Fisher & Paton, 1990; Gabriel, Grote & Jonas, 1981; Mann, Haddow, Stokes, Goodley & Rutter, 1986).

Handling the immature infant, whether for routine nursing care or medical intervention, has been implicated as a major stressor. Oxygen desaturation, cardiorespiratory abnormalities (Danford, Miske, Headley & Nelson, 1983; Long, Philip & Lucey, 1980; Norris, Campbell & Brenkert, 1982; Perelman & Volpe, 1982; Speidel, 1978), decreases in cerebral oxygenation and increases in intracranial blood volume and pressure (Brazy, 1988; Perelman & Volpe, 1983), and increases in catecholamine levels (Lagercrantz, Nilsson, Redham, & Hjemdal, 1986), have

been associated with care procedures. Handling is also a likely factor in the elevated plasma beta endorphin levels noted in ventilated infants receiving chest physiotherapy and suctioning (Hindmarsch, Shankaran, & Watson, 1984). Indeed, Murdoch and Darlow (1984) demonstrated that 93% of bradycardias as well as 81% of oxygen desaturations and 38% of apneic episodes occurred in connection with handling. The role of handling per se is underscored in data showing that eliminating chest physiotherapy and decreasing the frequency of suctioning, along with increasing inspired oxygen, reduces adverse blood pressure response (Omar, Greise, Ibrahim, Youssef & Friis-Hansen, 1985). Similarly, the incidence of oxygen desaturations was decreased when nurses were encouraged to observe the relationship between manipulations of the infant and oxygen saturation levels displayed on the transcutaneous oxygen monitor (Long et al., 1980b).

These studies have not only shown that specific aspects of intensive care are experienced as stressful, but also that modifying existing procedures can to some extent reduce their negative impact. On the basis of this research a 'developmental' approach to intensive care designed to protect the infant from stressors to which he or she cannot adequately respond without destabilization, and to provide external supports to compensate for abilities that have not yet matured, is being widely advocated (Als et al., 1986; Lawhon, 1986). The caretaker is challenged to provide an environment that supports development in the physiological, motor, and behavioral state systems, which in turn support the ability to attend to, and thereby to engage in, proactive interaction with the physical and social environment.

The developmental approach specifies that interventions, whether for care procedures or social interaction, be individualized on the basis of the infant's current status (Als, 1983; Gorski, 1983). This requires that the caretaker be able to recognize when the infant has become destabilized, or stressed, and alternatively, is stable and able to tolerate stimulation. Infant stress response has most often been studied in terms of cardiorespiratory or neuroendocrine parameters (Anand & Hickey, 1987; Wolke, 1987), but there is now also a considerable literature identifying behavioral signs of stress related to visceral, motor, behavioral state, and attentional systems (Als, 1983; Gorski, Lewkowicz & Huntington, 1987). Although there is disagreement about the degree to which specific behaviors are reliable indicators of stress (Gorski et al., 1987; Davis & Calhoun, 1991), measures of both motor activity and behavioral state have been related to stressful stimuli. An increase in the amount of motor activity and a decrease in the coordination of individual movements have been associated with intrusive procedures (Frank, 1986; Davis & Calhoun, 1989). Diffuse motor activity, in turn, is known to represent a significant drain on the energy resources of the fragile infant (Mestyan, Jarai & Fekete, 1968; Yeh, Lilien, Leu & Pildes, 1984). Increases in motor activity in response to aversive conditions usually occur in the context of changes in behavioral state, most notably an increase in non-alert active wakefulness and in fussing or crying, and crying has been associated with a decrease in arterial oxygen tension (Dinwiddie, Kumar, Patel & Fox, 1976) and an increase in cerebral blood volume (Brazy, 1988).

A primary emphasis of the developmental approach to care is on reducing environmental sources of stress by lowering noise and light levels. A second emphasis is on reducing the physiological and behavioral destabilization associated with procedural handling by use of facilitating actions that provide support, or containment, allow the infant 'time out' when thresholds to stress

are exceeded, and provide aids for self-regulation, such as pacifier or object to grasp. A third emphasis is on supporting motor development for the infant who is motorically and physiologically too immature either to maintain an appropriate flexed posture against gravitational pull or to control head and limb movements during handling procedures. This is accomplished by positioning the infant in ways which encourage flexion and discourage extension, and by providing containment to reduce diffuse and jerky movements. A fourth emphasis is on support for the development of the behavioral states of sleep and wake through preserving undisturbed rest periods and providing environmental cues for the development of circadian rhythms.

We have previously reported that a developmental approach to care implemented on a nursery-wide basis (Grunwald & Becker, 1991) was successful in changing nurse behavior, and that infants cared for after the developmental approach was initiated showed improved medical and growth outcomes, including lower levels of morbidity, shorter time to complete nipple feeding, a 2-week shorter length of hospitalization, and improved behavioral organization assessed at discharge (Becker, Grunwald, Moorman & Stuhr, 1991). The purpose of this report is to present results for the infants' physiological organization, motor activity and behavioral state organization during routine nursing care procedures. The research questions were:

1) Will infants receiving developmental care (study) show more optimal physiological values (heart & respiratory rates and arterial oxygen saturation); and more organized (flexor) and less disorganized (jerky) movement, particularly during periods when given positional support (containment)?

2) Will study infants spend more time during routine care in low arousal states (active sleep, drowse and alert) than in high arousal states (non-alert wake and fuss/cry) in the early weeks, and more time in alert wake in the later weeks?

Method

A phase lag design was used to study the effects of the developmental care program, with a control group of infants studied prior to program onset and a second group of infants studied after the program was instituted.

Sample and Setting

Subjects comprised a convenience sample of 21 control and 24 study infants and the entire nursing staff of an 18-bed NICU in a tertiary care center in a small city in the mid-west. Infants included in the study had a birth weight less than 1501 grams, were appropriate for gestational age (GA), and free of major chromosomal anomalies, congenital defects, or history of maternal substance abuse. Eligible infants were enrolled consecutively as they were admitted to the NICU. Informed consent for infant participation was obtained from the parents during the first week of the infant's hospitalization; only one family refused consent for participation. The intervention was implemented as a unit standard of clinical care, therefore informed consent was not obtained from staff nurses.

A total of 52 infants were enrolled in the study; one infant was dropped because of early transfer to the pediatric unit due to overcrowding in the NICU, and an additional 6 infants were dropped because they had been experimental subjects in a concurrent double blind clinical trial of surfactant therapy.

There were 14 male and 7 female infants in the control group, and 12 male and 12 female infants in the study group, and 5 multiple births in the control group and 3 in the experimental group.

Parents were largely middle class, and had at least a high school education. The majority of parents were Caucasian (86% in the control group and 83% in the study group). All but two families were intact. Groups did not differ on any infant or parent demographic variable (Table 1).

Insert Table 1 about here

Measures

Controls for phase-lag design. Measures were taken of patient/staff ratio, primary/non-primary nurse assignments, number of persons in the nursery, and changes in care protocols. None of these measures differed across periods.

Intervention. Developmental care was implemented using an initial education session and an ongoing program of training and support. The Neonatal Individualized Developmental Care and Assessment Program (Als & Gibes, 1986) was used for the introduction of basic concepts and education in the behavior and development of the premature infant, with an emphasis on recognition of physiological parameters and behaviors indicating that tolerance thresholds to stimuli have been exceeded. The 4-hour didactic session, supported by readings given to each nurse, was attended or viewed on videotape by all part-time and full-time staff nurses. This was followed by individualized instruction in the assessment of preterm infant behavior, involving observation and discussion of infant responses and recording of behaviors at 30-second intervals during routine cares using a standard coding form. Throughout the study period the neonatal clinician and occupational therapist provided the staff with individual guidance and evaluation, held inservices to review practice guidelines, trained new staff, and oriented medical house staff to the program.

Standards of nursing care were developed addressing six major areas: 1) supporting sleep/wake organization by clustering cares to allow uninterrupted rest periods and reducing light levels during sleep; 2) reducing destabilization during medical and caretaking interventions through provision of physical supports, aids for self-regulation (such as object to grasp or pacifier), and allowing time-out for restabilization; 3) promoting motor development by containing limbs to reduce random movement, providing support against gravity, and maintaining flexed positioning; 4) reducing environmental stress by reducing levels of light and sound; 5) supporting the development of feeding skills by offering nonnutritive sucking during gavage feeding and providing postural support during nipple feedings; and 6) sharing these approaches with parents. Various aids for implementing the standards were introduced, such as paneled covers for the incubators and covered hoods for open cribs to reduce the effects of continuous lighting while allowing variable degrees of visual monitoring; 'nesters' to provide the infant with boundaries and facilitate flexed positioning; clothing for even the smallest infants as additional boundaries; and pacifiers with handles to facilitate grasping and hand-mouth activity.

The effectiveness of the training program was evaluated by assessments of the noise and light environment and observations of nurse behavior during caretaking. Noise levels (dB, A-weighted scale) and light levels (lux) were assessed twice a week at room center and within isolettes, alternating day and night (Becker et al., 1991). Nurse actions were assessed by direct observation

of care procedures, along with infant behaviors, as described below. Behaviors included nurse location, caregiving activity, and facilitating actions. Facilitating actions included provision of physical support, containment with hands or swaddling, provision of aids for self regulation, support for flexed positioning, and offer of pacifier. Interrater reliability was assessed periodically throughout the study, and ranged from .79 to .91 (Cohen's kappa).

Noise and light levels were reduced, most dramatically within the isolettes and cribs, and diurnal patterns were introduced in the convalescent care nursery; facilitating actions increased significantly for all except offering of pacifier, which was common practice prior to the program (Becker et al., 1991) (Table 2). Thus the education program was effective in changing patterns of nursing care.

Insert Table 2 about here

Infant Outcome Measures. Physiological measures were recorded from the infant's monitors, and included heart rate and respiratory rate (per minute) (Hewlett Packard Cardiorespiratory Monitor) and percent arterial oxygen saturation (Nelcor Pulse Oximeter). The monitors were checked regularly by the hospital's respiratory therapy staff.

Infant behavior was recorded by direct observation, and included: 1) Motor activity, recorded as small, intermediate and large movements, jerky movement (startles, tremors/twitches, extensor movements) and flexor movements (grasping, hand to mouth or face, leg bracing). Measures were combined for this report as jerky, flexor, and total movement. 2) Behavioral states, recorded as quiet sleep, active sleep, sleep/wake transition, drowse, non-alert wake, diffuse alert, alert, and fuss/cry. States were judged on the basis of eye movement, activity level, respiratory characteristics, muscle tone, and vocalizations (Becker & Thoman, 1983). For purposes of this report, alert and diffuse-alert were combined into wake-alert. Interrater reliability of 70% or above in coding state and motor behavior (Cohen's Kappa) was established before the study and checked every 3 to 4 weeks throughout data collection.

Procedures

Nurse and infant behaviors were recorded during 18 minutes of routine care procedures twice a week during each week of the infant's hospitalization. Nurse behavior represents a nonsystematic sampling of the nursing staff. The identity of the nurse delivering care was not recorded, and the research staff had no involvement in staff assignments nor any previous knowledge of which nurse would be caring for the infant at the next observation. The NICU did not use a primary nurse model, although approximately one third of the staff elected to take primary care assignments during each period. Observations were separated by at least 2 days, and alternated between the day, evening and night shifts. Behaviors were recorded every 30 seconds, using an electronic timing device and a paper-and-pencil coding system. Physiological values were recorded from the infant's monitors at 2-minute intervals.

The range of gestational ages at birth was 26 to 33, and at discharge was 33 to 56. Because the number of subjects at the lower and higher ages was thus reduced, results are presented for the observations at 30, 32 and 34 weeks GA. Scores represent the mean of the two weekly observations for each infant at each age. Differences between groups and change across age were tested with MANOVA entering gestational age as a covariate, two-tailed t -tests for two means, and chi square analysis, as appropriate to the nature of the data.

Results

There were no differences in heart rate or respiratory rate by group or by age. Arterial oxygen saturation levels were significantly higher during observations at 30 and 34 weeks gestational age for study than for control infants (control means 88.84, SD 3.93, and 89.23, SD 3.77; study means 93.72, SD 1.66, and 93.25, SD 1.89). The F for group [df 1, 25] was 13.44, p <.001, for 30 weeks, and 7.86, p <.01, for 34 weeks.

Results for motor and state behavior are shown in Table 3. There were no group differences in total amount of motor activity at any age. However, the number of jerky movements was lower for study than control infants at 30 and 32 weeks, and decreased across age for both groups. The number of modulated flexor movements was higher for study than control infants at each age.
Containment occurred rarely in the control group. In the study group, disorganized movement occurred significantly less frequently in the presence of containment than with no containment. The percent of disorganized movement that occurred simultaneously with containment was 13% at 30 weeks, 9% at 32 weeks, and 8% at 34 weeks.

Insert Table 3 about here

Quiet sleep occurred infrequently in both groups. For each group, active sleep decreased and wake-alert increased from 30 to 34 weeks GA. Groups did not differ in the amount of time spent in active sleep, sleep/wake transition, drowse, non-alert wake, or fuss/cry. However, the amount of wake-alert was higher at 34 weeks for study than for control infants.

Discussion

Results demonstrate that a developmental approach to nursing care of very low birth weight infants was associated with a reduction in the incidence of selected indicators of stress and with more optimal organization of sleep/wake behavior over time. For the study infants, oxygen saturation levels during care procedures were higher, the incidence of uncoordinated motor movement was lower and coordinated movement higher, and by 34 weeks the proportion of time spent in alert wakefulness was higher than for the control infants.

The support for development of the alert state is of particular interest, as it is in this state that the infant actively processes visual information. The ability to attend is basic to general cognitive development, and indeed assessments of visual information processing have been shown to be more consistently related to later cognitive development than are the more traditional sensorimotor assessments, such as the Bayley Scales of Infant Development (Fagan, & Singer, 1983). An increase in alertness also has positive implications for social development. Indeed, results from one study (Rosenfield, 1980) show that maternal visiting patterns in the NICU were influenced more by the amount of alertness the infant displayed during the mother's visit than by the intervention program designed to increase mother involvement.

It is of interest that although the observations in the current study were relatively brief and did not include complete sleep/wake cycles, the results for alert wakefulness as well as active sleep demonstrated clear developmental trends in the expected directions. The reciprocal relationship between these two states

has been demonstrated in other longitudinal studies using longer observation periods (Denenberg & Thoman, 1981). Although these trends were not related to the intervention, they do support the validity of the data from these 18-minute observations.

The positive effects for motor activity also have potentially important implications for cognitive development, as controlled movements and flexor posture are important for the development of psychomotor skills, which rely heavily on smooth midline functioning. It is not clear why total activity was not decreased in the study infants, given that the amount of nurse support for flexor positioning and containment of diffuse motor activity increased significantly from control to study periods. However, the increase in flexor movement along with the increase in the alert state suggest how the developmental approach might contribute to mitigating deficiencies in visual-motor integration, a positive outcome that has been reported by Als et al. (1986) on the basis of 9-month follow-up assessments of infants receiving developmental care.

As this study involved an evaluation of practice by an entire nursing staff, it was not possible to exert tight control over the intervention, nor was it possible to match infants with nurses to control for variations across nurses. Thus attribution of group differences to the intervention must be made with caution. Nevertheless, the lack of control would, if anything, have made it more difficult to detect differences between control and study periods. In addition, the results support the findings of Als et al. (1986), who conducted a more selective implementation of the developmental approach to care. Together with our findings of improvement in medical and growth outcomes and behavioral organization at discharge (Becker et al., 1991), the results suggest that developmental care has the potential to also reduce longterm developmental morbidity among very low birth weight infants.

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Table 1. Sample Characteristics

	Control (N = 21)		Study (N = 24)	
	M	sd	M	sd
Mother's education[a]	2.93	.88	2.72	1.02
Gestational age (weeks)	28.38	1.28	29.00	1.93
Apgar. 1 Min.	4.85	2.11	5.33	2.28
Apgar. 5 Min.	6.68	1.49	7.12	2.05
Birthweight (grams)	1199.10	159.66	1208.54	222.94
Morbidity - Week 1	8.43	3.40	7.29	4.13

[a]Scored: 1 = < high school; 2 = high school or GED; 3 = technical school or some college; 4 = college or more.

Table 1. Sample Characteristics (continued)

	n	%	n	%
Gender of Infant				
Female	7	33%	12	50%
Male	14	67%	12	50%
Ethnicity				
Caucasian	18	86%	20	83%
Black	2	10%	3	13%
Asian	1	4%	1	4%
Multiple Birth	5	24%	3	13%

Note. Groups did not differ on any measure.

Table 2. Change in Nurse Facilitating Behavior from Control to Study Period for Observations at 30, 32, and 34 Weeks Gestational Age (GA)

Variable	F Period (df 1,34)	F GA (df 2,68)	F P x GA (df 2,68)	Contrasts
Containment	13.78•••	ns	ns	Control < Study
Postural Support	440.29•••	9.35•••	6.39••	Control < Study Week 34 < 30,32: Study
Pacifier	ns	3.03•	3.68•	Control < Study:GA 34
Total Number Facilitating Behaviors	9.56••	ns	ns	Control < Study

•p < .10. ••p < .05. •••p < .01. ••••p < .001.

Table 3. Infant Behavior during Caretaking at 30, 32, and 34 Weeks Gestational Age (GA)

Outcome Measure	F Period (df 1,34)	F GA (df 2,68)	F P x GA (df 2,68)	Contrasts
Total Movement	ns	ns	ns	--
Jerky Movement	10.85••	6.06•	4.87••	Control > Study: 30,32 30 > 32 > 34
Flexor Movement	5.41•	ns	ns	Control < Study
Active Sleep	ns	7.00••	ns	30 > 32 > 34
Wake-Not-Alert	ns	ns	ns	--
Wake-Alert	4.30•	9.34•••	4.32•	Control < Study:34 30 < 32 < 34

•p < .05. ••p < .01. •••p < .001.